Monitoring Study Group Meeting Minutes

June 17, 2003
Redding—CDF Northern Operations Center

The following people attended the MSG meeting: Tharon O'Dell (BOF-chair), John Munn (CDF), Dr. Jerry Ahlstrom (CDF), Dean Lucke (CDF), Tom Spittler (CGS), Dr. Michael Wopat (CGS), Dr. Rich Walker (CDF), Dr. Richard Harris (UCB), Sam Flanagan (NMFS), Duane Shintaku (CDF), Dennis Hall (CDF), Peter Ribar (Campbell Timberland Management), Mark Rentz (CFA), Clay Brandow (CDF), Tom Suk (Lahontan RWQCB), George Cella (Lahontan RWQCB), Dr. Russ Henly (CDF), Chris Keithley (CDF), Bob Rynearson (W.M. Beaty and Associates), Bernie Bush (SRCO), Matt House (SRCO), Dr. Morgan Hannaford (Shasta College), Dr. Cajun James (SPI), Brad Dorken (CDF), Bill Keye (CLFA), Sandra Brown (NRM), Gaylon Lee (SWRCB), Richard Gienger (HWC/SSRC), Ted Oldenburg (Hoopa Tribal Forestry), Kevin Colegrove (Hoopa Tribal Forestry), Jared Gerstein (UCB), Dr. Lee MacDonald (CSU), Dr. George Robison (HSU), Joe Croteau (DFG), Curt Babcock (DFG), Angela Wilson (CVRWQCB), and Pete Cafferata (CDF). **[Note: action items are shown in bold print]**.

We began the meeting with general monitoring related announcements:

- Richard Gienger stated that Randy Klein has summarized his first year monitoring work on 71 abandoned crossings in the Mattole River watershed. Surveys of the abandoned crossings have shown that downcutting following winter storm events has resulted in a loss, on average, of 16 yd^3 per crossing, with the largest loss being 51 yd^3.
- John Munn announced that as part of the MOU signed by CDF and the SWRCB, a monitoring task force has produced a draft MOU Monitoring Agreement for monitoring of timber harvesting activities. This document is a work in progress, with a draft for public review expected in early July.
- Pete Cafferata announced that the California Forest Soils Council summer field meeting will be held jointly with the California Forest Pest Council on July 22-24 in the Auburn area. For more information, contact Bill Morrison (SPI) at (530) 272-2297 or bmorrison@spi-ind.com
- Pete Cafferata announced that the Northern California Section of SAF is having its summer meeting in Santa Rosa on June 27/28th. The meeting is titled "Keeping Working Forests Working." For registration information, contact Sherry Cooper, UCB, at shcooper@ucdavis.edu or (530) 224-4902. For the meeting agenda, see: http://www.humboldt.edu/~norcal/temparticles/2003.Summer.Mtg.pdf
- Cajun James announced that she is putting together a water quality monitoring workshop with an anticipated date of early October. Co-sponsors of the workshop include CDF and UCB—Center for Forestry. Expected speakers include Dr. Bob Beschta (OSU), Dr. Lee MacDonald (CSU), and USFS-PSW researchers. For further information, contact Dr. James at cjames@spi-ind.com or (530) 378-8151.

Sam Flanagan provided a PowerPoint presentation titled "How Culverts Fail…and What to do About it." This presentation was based on studies funded by HSU, USFS, CDF, and NACASI that were conducted in Northern California and the Pacific Northwest from 1992 through 1998. Individual projects included: woody debris transport through low-order channels: implications for culvert failure (1992-1996), field indicators of culvert capacity (1997), and response of road-stream crossings to large flood events in the PNW (1996-1998).

Sam presented a four-part conceptual model/flowchart displaying the environmental risk of crossings. The four risk components are inputs, capacity, consequences, and endpoints. Inputs include woody debris, sediment, streamflow, and fish. When capacity is exceeded, inputs accumulate and physical consequences can result, including water quality impacts. Endpoint impacts can be to cold-water refugia, domestic water supplies, and sensitive aquatic species (e.g., fish species). The presentation focused on the inputs and capacity components.

Detailed information was provided on how crossings fail. The failure mechanisms for 258 crossings associated with very large, infrequent storms for the PNW/Northern California region were displayed (recurrence intervals exceeded 100 yrs in some locations). Sediment slugs accounted for 36% of the failures; debris torrents, 26%; wood debris, 17%; wood/sediment, 12%; and hydraulic exceedence, 9% (see Furniss et al. 1998, Response of Road-Stream Crossings to Large Flood Events in Washington, Oregon, and Northern California). Once field personnel were present at a failed crossing site, it usually was not exceptionally difficult to determine the cause of failure—if one was willing to use a shovel and dig out the culvert inlet area. The failure mechanisms associated with very large, infrequent storm events were compared to failure mechanisms for culverts in Northwestern California associated with storms with recurrence intervals less than 12 years. In this case, wood debris accounted for 61% of the failures; wood/sediment, 18%; hydraulic exceedence, 12%; sediment slug 7%; and debris torrent, 2%. Clearly, for more frequent storms, the dominant failure mechanism is wood accumulation at the inlet. Typically, the type of wood causing failures is small (i.e., twigs and small sticks), not large logs. The main hazard is small wood—not large wood.

These latter conclusions were reached following collection of data on 26 low-order channels in Northwestern California for Sam's graduate research conducted at Humboldt State University. The small streams were located in the Bull Creek, Pilot Creek, and Coyote Creek watersheds. Channel widths ranged from 1 foot to 11.5 feet and culvert sizes ranged from 18 inches to 60 inches in diameter. Collection "fences" or debris screens (6 inch square mesh) were built across each stream below the culvert outlet and the accumulated material was examined after each peak flow event. The length and diameter of each piece of wood was recorded and the channel dimensions were re-measured. Sam found that the length of 99.5% of the wood transported through the low-order channels was less than the active channel width (i.e., zone of active, annual scour and deposition).[1] In other words, the length of fluvially transported pieces of wood that can cause culvert failures with storms that occur more frequently than every 12 years are commonly less than the active channel width. Therefore, to address wood passage and minimize the chance of failure from this mechanism, it is appropriate to install a pipe diameter that approximates the active channel

[1] Active channel width can be determined by making 10 systematic measurements of the channel width at 5 m intervals above the inlet (beginning 5 m above the inlet), and obtaining an average width.

width. This reduces, but does not eliminate, the plugging hazard. Additionally, while multiple, smaller pipes at a crossing site will handle additional water discharge, they are not a suitable means of providing wood passage.

Inlet geometry is also very important for wood passage through small culverts, since it strongly influences wood orientation as it approaches the inlet. When channel width increases near the inlet, debris plugging is more likely. Also, culverts that allow water to pond in front of the inlet are generally more prone to failure, since this allows small pieces of wood to rotate and collect at the inlet opening. Straight, narrow channel approaches promote debris passage, and specifying a headwater depth/diameter (HW/D) ratio less than one limits ponding in front of the inlet. Similarly, culverts oriented at a significant angle from the stream channel are susceptible to plugging, so the pipe should be kept straight with the channel. These types of field indicators can be used to assess the risk of failure with existing crossings, as well as for guidelines for new culvert installation (see Flanagan et al. 1998, Methods for Inventory and Environmental Risk Assessment of Road Drainage Crossings; http://www.bof.fire.ca.gov/pdfs/handbook.pdf); Flanagan and Furniss 1998, Field Indicators of Stream Crossing Capacity).

Sediment failure mechanisms were covered next. Large storm events (with recurrence intervals in excess of 20 years) trigger a greater proportion of sediment related failures when compared to more frequent storms. Sediment can be broken down into two types: fluvial bedload sediment delivery, and catastrophic sediment delivery (e.g., landslides and debris flows). To address routine bedload transport, it is critical to avoid placing relatively flat pipes on steep streams (i.e., the pipe should be at approximately the same gradient as the channel slope) to avoid bedload accumulation. To address debris flow hazard, it is important to remember that there is no way to install a culvert to pass a debris flow. Rather, the goal is to minimize the interference that the crossing presents in the path of the debris flow. One way to do this is to avoid building critical dips directly over the crossing or in the potential path of the debris flow. The relief dip needs to be constructed on the downhill side of the crossing and should be heavily armored with rock (i.e., a rocked ford crossing).

Failure mechanisms due to insufficient hydraulic capacity were then covered. In forested, mountainous terrain, excessive amounts of water alone are typically the least frequent cause of failure. This concept goes against conventional wisdom, since forest practice rules have typically been written specifying passage of a 50 or 100 year flood flow. Sizing for hydraulic capacity may or may not address what is likely to cause culvert failure, but it appears that it is only minimally a useful measure for addressing failure hazard. One reason for this it that increasing a pipe size one increment (6 inches) greatly increases its hydraulic capacity, but does little to increase wood passage. The data collected in Northwestern California shows that sizing for a 100-year water flow does not ensure adequate sizing for wood passage. On average, sizing for a 100-year flood flow produces a pipe diameter that is only about two-thirds the channel width (i.e., culvert diameter/channel width = ~2/3). In contrast, if the culvert is sized for wood passage (i.e., pipe is approximately equal to active channel width), it typically ensures adequate hydraulic capacity for 100-year flood flows or greater.

Finally, failure mechanisms for culverts on small alluvial fans were considered. Roads, particularly located on low slope positions, commonly traverse small alluvial fans. Typically during high flow events, the channel present when the road was built is abandoned and no culvert is present on the road to accommodate the new channel location. Therefore, it is appropriate to install relief culverts or critical dips on each edge of the alluvial fan and at the existing channel to ensure that the flow can be accommodated when channel migration occurs.

In summary, more frequent storms cause failures by fluvial mechanisms—wood transport and fluvial sediment—and we can reduce failure probability for these events. Channel dimensions should drive culvert sizing, including active channel width and channel slope. It is critical to avoid culvert sizing that creates ponded conditions at the inlet. Sizing for a 100-year flood flow does not ensure adequate capacity for debris and sediment. Large, infrequent storms cause hillslope failures that initiate landslides and debris flows—and we can reduce failure consequences for these types of events (these are not culvert sizing issues). It is important to avoid diversion potential, and be aware of the potential consequences of debris flows and adjacent slides overwhelming remedial dips. It is also important to remember the simple goal of keeping watershed products moving downslope, not across the slope. Observe existing culverts and channels, since they can often indicate causes of past failures. Examples of these situations include dented inlets from repeated excavations, depositional terraces in the inlet basin, and debris flow levees. Clearly, we cannot completely avoid failures, but we can reduce failure potential through careful crossing design that accommodates water, wood, and sediment, and that reduces potential erosional consequences when they do fail. Sam's PowerPoint presentation is available on CD ROM. For a copy, contact Pete Cafferata (pete.cafferata@fire.ca.gov).

Following Sam Flanagan's presentation, Pete Cafferata provided the group with a brief update on the three cooperative instream monitoring projects that are starting this year. For the South Fork Wages Creek project with Campbell Timberland Management, CDF has purchased pumping samplers, automated rain gauges, recording turbidity probes, staff plates, data loggers, and instrument enclosures. Currently, four automated stations are planned for the winter of 2003/2004. The study plan for the project is nearly completed and is expected to be delivered to CDF by June 25th. **Individuals wanting to review the document prior to the next MSG meeting, when we will discuss it in depth, should contact Stephen Levesque** (slevesque@campbellgroup.com). For the SPI cooperative project, CDF has purchased four YSI Sondes with turbidity and DO probes, four data loggers, and four pressure transducers. Cajun James will decide in the next couple of weeks the final watershed to be monitored in the Weaverville SPI district. A planning watershed will be chosen with at least three subbasins that can be instrumented, two of which will receive differing silvicultural treatments, and one that will serve as a control. Additionally, a downstream station will be installed. For both the SPI and Campbell cooperative projects, an MOU will be written documenting the goals of the project, contributions of each participant, and timeline for project implementation. Regarding the third project, CDF's Contracts Office is preparing a contract with the Mendocino County RCD for a second phase of the Garcia River cooperative instream monitoring project. CDF will primarily be supplying funds to purchase monitoring equipment for this project was well. Cooperators in the Garcia project include the NCRWQCB, the landowners, the MCRCD, and MSG/CDF/BOF. Five of the 12 tributaries monitored in 1999 will be instrumented with continuously recording turbidimeters and turbidity spikes will trigger hillslope/channel inspections. Additionally, instream gravel composition and permeability will be remeasured at these five tributaries.

Following lunch, Dr. Lee MacDonald, Department of Earth Resources, Colorado State University, provided a PowerPoint presentation titled "Measuring and Modeling Cumulative

Watershed Effects in the Central Sierra Nevada." Work on this project was funded by the Eldorado National Forest, U.S. Forest Service, CDF, NCASI, and others. Field data was collected by Drew Coe, CSU graduate student, on the Eldorado National Forest and SPI timberlands, and GIS analysis has been completed by CSU graduate student Sam Litschert. The goal of this work has been to collect field measurements that can be used, in combination with exiting data, to develop a new generation of procedures for assessing cumulative watershed effects (CWEs) on small basins (2,500 acres to 25,000 acres). The focus has been on measuring and predicting sediment production and delivery at the hillslope scale. The work to date has yet to be published. Drew Coe's masters thesis is in preparation.

Currently available techniques to assess CWEs range from qualitative checklists to quantitative, detailed, high cost models (e.g., SEDMOD2, DHSVM, etc.). The USFS Equivalent Roaded Area (ERA) model can be characterized as a lumped conceptual model that does not explicitly separate changes in flow from changes in sediment, and uses excessively long recovery curves. Additionally, there has been little validation for this model at the site or watershed scale. The goal of the current work is to develop techniques that can be described as conceptual, empirical models that are more accurate than checklists and the ERA approach, and easier to use than the detailed, high cost modeling methods.

Specific objectives of the research included: 1) measuring sediment production from roads, fires, and harvest units over 3 years, 2) determining primary controls on sediment production rates, and 3) developing spatially explicit models to estimate cumulative effects on smaller watersheds. Sediment fences were installed on a variety of areas to measure sediment production (for detailed information on sediment fence installation, see: http://www.fs.fed.us/rm/pubs/rmrs_gtr94.pdf). Fences were installed for roads, harvest units, off-road vehicle areas, fires, and minimally disturbed areas. Over 150 fences were installed over 3 years, accounting for nearly 400 fence-years of data. First year data collection (1999-2000) revealed that native surface roads and off-road vehicle areas generated large amounts of sediment, but production rates were highly variable. Most of the fire sites had low sediment production, except for the first year following the Pendola Fire on high severity burn sites (i.e., all or nearly all of the vegetation, litter, and organic matter gone). Sediment yield from the Pendola Fire sites decreased by approximately an order of magnitude for each year (2000-01 and 2001-02) following the first winter. Prescribed fire sites had very low sediment production. Harvest unit sediment production was mostly low, except for a few sites on older harvest units with granitic soils. In most cases, skid trails had much lower sediment production compared to roads. The first winter monitored was the wettest of the three years, while the second was drier and colder. The third winter was intermediate in terms of total precipitation and the duration of snow cover.

Since roads were found to be a very significant area for sediment generation, additional fences were installed on roads following the first winter season. Data analysis showed that road area (defined as the contributing area between drainage structures) multiplied by slope (A*S) was the key variable for prediction of sediment yield. This variable alone predicted 55% of the sediment production from native surfaced roads. Recently graded native surface roads were found to produce twice as much sediment as comparable segments that had not been graded. High interannual variability in sediment production was observed on native surface roads and the first winter season produced considerably more road sediment when compared to that produced in the second and third years. Rocking was very effective in reducing sediment production; rocked roads produced two orders of magnitude lower amounts of sediment when compared to native surface roads. The highest sediment production rates were often associated with insloped road segments located downslope of areas with shallow, impermeable bedrock (i.e., roads located on lava cap areas). Where soils were shallow, stormflow was rapidly routed into inside ditches, producing higher sediment yields.

The predictive model for sediment production for road segment erosion had an r^2 of 0.62 and included the following variables: area x slope (A*S), graded/ungraded, annual precipitation, elevation, and road contributing area. The following three variables were able to explain about 50% of the variability in the data: area x slope (A*S), rocked/unrocked, and an erosivity index. These field measurements were much lower than estimates of sediment production from the Water Erosion Prediction Project (WEPP) model projections for insloped and outsloped roads, but it is important to remember that no large storm events were monitored from 1999 to 2001.

The central Sierra Nevada sediment study work also included an evaluation of sediment delivery to stream networks. A survey of 285 road segments indicated that 18% of the segments (20% by length) had gullies or sediment plumes that reached to within 33 feet of a stream channel (where they were considered connected). Watercourse crossings accounted for approximately 60% of the road segments connected to the stream network. The remainder were connected by gullies initiated below waterbars and rolling dips, or gullies initiated below cross drain culverts. In general, it is easier to predict sediment production from road segments than it is to predict true sediment delivery to the channel (since slope, hillslope roughness, etc. must be considered and are highly variable). Sediment production and delivery were also estimated for upland landslides from 27 study watersheds in the Eldorado National Forest. Overall, upland landslides appear to be producing less sediment than road segments for the central Sierra Nevada area. Estimated landslide delivery rates were comparable to those found in the published literature.

Next, Lee spoke about his modeling goals for the project. These included: 1) explicitly separating changes in flow from changes in sediment, 2) calculating changes on a watershed scale using spatially explicit procedures, 3) summing effects from multiple activities, 4) using a modular approach to allow for additional land uses, and 5) allowing users to select the magnitude of change and rate of recovery. An important goal is to produce models that are readily useable by resource specialists. Currently, three modules are envisioned: Delta-Q for flow (currently available and distributed at the MSG meeting; copies of the CD ROM are available from Sam Litschert—email her at sam@cnr.colostate.edu), SEDPROD (expected to be ready in 3 to 6 weeks), and SEDELIVERY (no time estimate given for release). Delta-Q calculates the changes in low, median, and high flows from forest management and fires; SEDPROD calculates sediment production from forest harvest areas, roads, and fires; SEDELIVERY calculates sediment delivery to the stream network and downstream travel rates to the reach of interest.

No paired watershed data is available for the Sierra Nevada Mountains for the Delta-Q module, so the CSU team used data from 30 paired-catchment experiments in the literature to evaluate the changes in flows following changes in land use. They analyzed changes in selected flow percentiles by comparing pre- and post-treatment flow duration curves, and adjusted the flow duration curve on treated basins for changes in flow observed from the control basin. In general, the predicted change is an increase of from 10 to 15% for very high discharge flood events following treatment. Cumulatively for the basin, the module predicts very small percent changes in peak flows (with the possible exception of impacts from large intense fires).

Regarding the SEDPROD module, inputs include: the watershed spatial layer, year of activity and type of activity, controlling factor (soil type, fire severity, road slope, etc.), background or undisturbed sediment production rate, number of years to recovery, and years to simulate (beginning and ending). Outputs include a table of sediment production summarized by year. Modeling changes in sediment is much harder than modeling changes in flow due to the delivery issue. Lee noted that most assessment procedures, including this one, are more useful on a relative scale than on an absolute scale due to imperfect landscape knowledge, problems with quantifying cause and effect relationships, and the inability to validate complex models. Modeling efforts will always be plagued with a limited amount of data, both in the Sierra and elsewhere.

The alternative to modeling is using adaptive management to address CWEs. This method may not be a viable approach, however, since it requires regular monitoring and rapid feedback to managers, a close linkage between management and resource response, the ability to rapidly detect change, and minimal persistence of adverse effects. Lee cautions that we need to be realistic in our expectations about adaptive management.

The next steps in this continuing effort to model cumulative watershed effects include collecting existing data (USFS, industry, state, UC, etc.) and making it available for modeling purposes, initiating studies in other areas using sediment fences (Lee's next study sites are in the Sierra and Lassen National Forests), evaluating road connectivity in other areas (different geologic types, climatic regimes, slopes, etc.), evaluating further sediment production and delivery from wildfires (the equivalent of North Coast landslides for the Sierra), constructing sediment budgets for sensitive watersheds in the Kings River watershed basin, and completing and distributing the SEDPROD module.

Several conclusions were presented based on the central Sierra Nevada research: 1) native surface roads, high-severity fires, and mass movements are dominant sources of sediment, 2) very high variability in sediment production is observed between sites and between years, 3) most roads are not connected to streams except at crossings, 4) relatively few sites contribute most of the sediment to the stream network, 5) management induced changes in sediment are usually more important than changes in flow, 6) improved models are needed to assess and predict cumulative watershed effects, 7) model calculations and predictions are not truth; 8) model validation is difficult at both the site and watershed scale, 9) it is more difficult to use adaptive management for cumulative watershed effects because of long lags in response, long recovery periods, difficulty in detecting change, and difficulty of relating an observed change to a given management action, and 10) the implication is that the greatest focus should be placed on ensuring each action has minimal effect on the local scale.

Due to time constraints, the new and unfinished business and public comment agenda items were not completed.

The next MSG meeting was tentatively scheduled for the week of August 11th; the specific day will be determined and emailed to the MSG mailing list.